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BUSINESS PROBLEMS OF THE MOTIVE POWER DEPARTMENT.

AN ADDRESS

DELIVERED BY

ROBERT QUAYLE,

SUPERINTENDENT OF MOTIVE-POWER AND MACHINERY,
CHICAGO & NORTHWESTERN
RAILWAY COMPANY.

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OF

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VIII.

BUSINESS PROBLEMS OF THE MOTIVE POWER DEPARTMENT.

ROBERT QUAYLE.

SIXTY-FIVE years ago railroads were practically unknown. History records their small beginnings with crude equipment. Strange looking locomotives were used that weighed hardly more than a modern dray. The cars were modeled from the stage coaches of that time, and they were run on track of the most flimsy character. The speeds were slow and the service very uncertain, but from this small and crude beginning evolved the world's great systems of rail transportation, which in this country alone aggregate over 184,000 miles of track, and

require in the conduct of its immense business 36,000 locomotives, 34,000 passenger cars and 1,200,000 freight cars, while the capital employed is calculated by hundreds of millions, and the great army of employes by hundreds of thousands. The development of the resources of our country resulting therefrom has been remarkable, and the advancement of civilization not less notable.

It goes without saying that the financial and commercial problems involved in the creation and operation of these great properties—complicated as the situation often was by the fact that railroad construction did not wait the development of the country, but was generally in the lead and opened up the way for it—have become complex in character and of great magnitude.

It is not my purpose, however, to dwell upon the wonderfully rapid growth of our railroads, nor the effect upon the prosperity of our country, nor even upon the business and financial problems arising in the government of these great properties as a whole, but rather to take the situation as

we find it to-day and to give you some insight into a few of the business problems of the motive-power departments of fairly large railroad corporations.

To many of you, who have for several years been studying various branches of engineering and fitting yourselves for battling successfully with the many technical problems that are sure to confront you in the practice of your chosen professions, it may appear as if the technical problems requiring solution by those in charge of motive power, are more numerous, if not more important, than the business problems they are called upon to solve. That this is not the case will be clear upon proper reflection. You have doubtless learned, under the excellent practical instruction you have received at this university, that every engineering question has its commercial and business side; and the importance of always seeing this side and giving it due prominence will be impressed upon you more and more as you add to your experience in the practice of your profession. In fact, every situation or condition of

affairs that requires the services of the engineer calls for the production by him of structures or mechanisms that will not only meet the requirements of the situation but will do it with a minimum expenditure of capital, or will give the greatest returns from the investment. The successful engineer is he whose judgment is so trained that the capital of those who depend upon it will be wisely and safely invested. He must not only answer such questions as, "Can this or that be done?" and "How can it best be done?" but he must give equally reliable answers to such questions as, "Will it pay to do it?" Thus, the rule is that his engineering problems are closely interwoven with considerations of a commercial nature. The conduct of a motive-power department of a large railroad system forms no exception to this rule.

In the earlier days of railroading the duties of General Manager, Superintendent, Master Mechanic, etc., were usually performed by one person, but as the business became more extensive it was found necessary to divide the work among

several men, each with specific duties and responsibilities, and as the business still further increased, the division of the duties became more complete, and the organization was separated into numerous departments, each with a certain designated work to perform, and the work of all to be directed to the welfare of the organization as a whole. The mechanical or motive-power department is one of these several departments in such an organization, and its duties involve the design, construction, maintenance, and operation of the locomotive and the supervision of the men who operate it, except as these men come under the rules and direction of the operating department. The end for which the department was created is of course that of keeping the wheels turning. It must be apparent, however, that as one of the many departments it is necessary to make the work of this one to fit into the needs of the others, and to so conduct its own affairs as to bring them in harmony with the aims and resources of the organization as a whole. This might properly be designated as the grand business problem of

the department. The department is not an isolated organization, but is closely interwoven, in its work and interests, with the operating and other departments, and to successfully carry on its business there is need of a breadth of mind that will clearly discern the relations of the motive power to other departments, and the effect of any given policy within the department upon the work of the others; for a policy that looks all right when viewed only from the standpoint of the single department may be all wrong when considered in its effect upon the organization as a whole. If the carrying out of a certain policy would result in a saving in the mechanical department of \$10,000 per year, but would involve expenditures in other departments of \$10,500, it would not be justified, unless the benefit to the company through the improvement of its service would be worth the \$500 increased expenditure. Thus at the outset we find that what we might call the external relations of the department form a problem that can be solved only by the application of strictly business principles, and we will

see later on that the effect is so far-reaching as to have an influence even on locomotive designs and shop practices. To ignore these facts is to travel in ruts that are constantly narrowing and deepening until the best work of the mechanical department is wholly lost to the company.

Before turning to the problems within the department it may be well to give you some idea of its expenses, from which you can judge of the magnitude of its problems. The average cost of the locomotives may be placed at \$9,000, while the average capital expenditure per locomotive for round houses, shops, tools, etc., is in the neighborhood of \$5,000. Thus each locomotive and the equipment necessary to take care of it represents an approximate expenditure of \$14,000.

The cost of the operation of the locomotive includes the fuel, oil, waste, enginemen's wages, round-house labor, cost of repairs and supplies. The cost of the fuel varies in different localities, being less than one dollar per ton for coal in some eastern districts and more than five dollars in parts of the far west. If, however, we assume

an average of \$1.75 per ton for coal we will not be far out of the way.

We will also assume that an engine runs 26 miles to a ton of coal, and makes 36,000 miles per year; then the cost of fuel per annum will be \$2,423. The wages of the engineer and fireman will average about 6.2 cents per mile, and all round-house labor will average about 1.4 cents per mile, or a total for labor of 7.6 cents per mile, or \$2,736 per year. The oil and waste will cost about .2 cent per mile, or \$72 per year. The repairs and supplies will cost approximately 4 cents per mile, or a total of \$1,440 per year. The cost of water we will estimate at .2 cent per mile, or \$72 per year. We thus find the several items of "cost of operation" to aggregate \$6,743, exclusive of all interest charges on capital employed. It is not unusual for large railroad systems to possess 500 locomotives, and quite a number of them own more than 1,000. From the above figures it will be seen that the operation of 500 locomotives calls for an average expenditure,

through the mechanical department, of \$3,371,500, and for 1,000 engines the sum becomes \$6,743,000 per year. It is, therefore, needless to say that in the expenditure of such large sums as these, and the treatment of a portion of a company's business so important and having such an important bearing on its interests, every problem, no matter what its character, has its business side as distinguished from its narrower or purely technical nature.

Turning now to affairs within the department, we find that there are several important problems in connection with the operation of the locomotive and the service it renders the company. We all look upon the locomotive with a great deal of sentiment, the proof of which is constantly forthcoming in the interest manifested in its performance. Every account of a fast run is read with interest by the general public, as well as by the railroad men, and we are thrilled by the records of great bursts of speed made on the rails. The modern locomotive, with its great boiler and generally massive and powerful appearance, hauling

a passenger train of ten or twelve long, heavy cars at the rate of forty-five or fifty miles per hour, gives an impression of majesty and power not soon forgotten by the observer, who is only far enough away from it to be safe. And as we stand in the depots in some of our large cities and see these trains arrive, at the end of their long and rapid journeys of one thousand miles or more, often on time to the minute, and realize that in daylight and darkness, sunshine or storm, they sweep over great plains, and over or through mountain ranges, sometimes toiling slowly and powerfully up heavy grades only to dash with renewed speed down the mountain sides and into the valleys, that this great burden has been carried such immense distances in safety by machinery that is the creation of man's ingenuity and industry, we feel that it is indeed wonderful. Our great freight locomotives, of slower speed but of much greater weight and power, also engage our attention as we see them coupled to fifty, sixty, or more, loaded cars working heroically to reach their destination on time.

II

Many students of the steam engine are interested in the performance of the locomotive as a heat motor and peruse carefully the figures for the coal and water consumption obtained by elaborate tests, and are gratified to note the economy obtained as the result of gradual improvement in design. The motive-power official may possess his share of sentiment, and certainly should be alive to all improvements that will increase the economy of the locomotive as a heat engine, but he must also look upon his motive power from a far more business-like standpoint. He must consider the locomotive as a machine—a tool created for a purpose—representing a large investment of capital and costing annually a considerable sum for its operation, and must be deeply concerned in making it give the largest possible return to the company. If to attain this end he must violate, in the construction or operation of the engine, principles which he knows tend toward economy of water and fuel, it is his business to do it. And I have no hesitation in saying that to the carrying out of this wise and business-like policy are due

some features of locomotive practice that are sometimes condemned by those who are apt to look upon the subject entirely from the standpoint of economy in fuel.

Perhaps I can best illustrate this business problem by a comparison which every motive power official has had to make at some time, in connection with the rating of his engines. The tests that have been made upon the locomotive in the testing laboratory of this university demonstrate that the most economical point of cut-off is between one-quarter and one-third of the stroke. Other tests made on this same plant show that as the locomotive boiler is forced and the rate of combustion increased, the rate of evaporation falls off rapidly. The conclusion is therefore warranted that with a given speed a cut-off later than one-third of the stroke will result in a loss of economy, both in the boiler and the cylinders. Are we, therefore, warranted in endeavoring to operate our locomotives under these conditions of maximum fuel economy? The work of the engine varies so much with the grades that we can

not expect to run at a uniform rate of cut-off, but is it economy to endeavor to give the locomotive such a load that it will average one-quarter to one-third cut-off? Let us look into the question. Suppose ours is a nineteen inch engine in freight service on a hilly division and that under a limitation of the average cut-off to one-third, the tonnage which it can haul over the division is six hundred tons, exclusive of its own weight and that of the waycar. Let us further assume that if the engine is worked to its utmost capacity on the ruling grades, even if by so doing we must run it for many miles at from one-half to full stroke, we will be able to haul seven hundred and fifty tons. The train and engine crews' wages will amount to about 13.2 cents per mile or \$13.20 per one hundred miles. When hauling the heavier train we are getting 25 per cent. more tonnage over the division for the same cost in wages, and thereby effecting a saving of \$3.30 for each hundred miles the seven hundred and fifty tons are hauled. This is a clear gain in operating expenses. Now, let us

look at the actual consumption of fuel and in doing this we must bear in mind that while our nominal weights of trains are six hundred, and seven hundred and fifty tons, respectively, the real weights, allowing one hundred tons for the engine and tender and fifteen tons for the waycar, are seven hundred and fifteen, and eight hundred and sixty-five tons, respectively. Evidently the weights of the engine, tender and waycar form a fixed quantity in our calculations and that the heavier the train the less the percentage of the total work of the engine needed to overcome their resistance, and the internal resistance of the engine. Evidently the coal consumption in our comparison should be figured on the basis of the tonnage of the cars and their contents only, for upon this is based the earnings of the train. For the six hundred ton train the coal consumption may be taken at say seventeen pounds of coal per hundred ton-miles, or ten thousand two hundred pounds to haul the train one hundred miles. For the seven hundred and fifty ton train the consumption

per hundred ton-miles will be about one and one-half pounds less, or say fifteen and five-tenths pounds per hundred ton-miles. In other words, the lesser percentage of the total work of the engine expended upon itself, its tender and the way-car, more than offsets the increased consumption of coal per indicated horse power. The total consumption for the seven hundred and fifty tons hauled one hundred miles will be about eleven thousand six hundred and twenty-five pounds. Thus, while the total consumption of coal per trip is of course greater for the heavier train, the consumption per hundred ton-miles is less; consequently the fuel bill to haul three thousand tons of cars and contents will be less if it is taken over the road in four trains of seven hundred and fifty tons instead of five trains of six hundred tons. So we have saved money in both wages and fuel per hundred ton-miles. But the question is broader still. Evidently fewer engines resulting in a lesser investment are required; furthermore, while the cost of repairs per mile run by the engine may be greater, the cost per hundred ton-miles of train

hailed will be less. Again, the fewer engines will mean a smaller investment in round houses, shops, machinery, etc., and last, but not least, the operating expenses will be reduced in more ways than train crew wages, and the liability of accident will be lessened by the fewer number of trains. Thus the broader the light in which this question is viewed the greater the economy of working the locomotive beyond the point of maximum economy per indicated horse power.

That this view of this business problem is correct will be acceded to by every motive-power official. The situation may appear to you to be paradoxical, particularly in regard to the item of fuel, but that coal can be saved by loading an engine heavily we have proof of daily. The road with which the writer is connected keeps an individual coal record by which the consumption of coal per hundred ton-miles by each engineer is recorded. In a group of men in comparable freight service on one division the best performance in November last was fifteen and nine-tenths pounds per hundred ton-miles, the engineer having an average

train of eight hundred and fifty-three tons. The poorest record was twenty-eight and seven-tenths pounds, but the average train was only three hundred and seventy-eight tons. Of course there are differences in engines, which was true in this case, but all our coal accounts support the statement that, other things being equal, the heavier the train the less the consumption per hundred ton-miles. The limit to this rule is not reached before the engine is so overloaded that the required time can not be made. So evident is this to our engineers that they are anxious to haul the heaviest trains of which their engines are capable, as by this means only will their records compare favorably with others in the same class of work.

This same mode of reasoning, by which the work of the engine is viewed by its effect upon the net cost of hauling tonnage rather than its economy in fuel per horse power, must apply to other questions involved in locomotive construction and operation. On this basis the size of locomotives have been constantly increasing and

will continue to increase. Anything which adds to the economy of performance, but limits the amount of work that can be obtained from the engine, either by reducing the tonnage it can haul per trip or reducing the mileage it can make per year, can not hope to succeed. If a complicated valve gear would save five or ten per cent. in fuel, but would cause the engine to miss a trip occasionally because of repairs necessary to the mechanism, the loss of the service of the engine to the company in busy seasons would possibly more than offset the saving in fuel. On the other hand, simple, strong and reliable construction of the locomotive, facilities for quickly repairing it, and everything that will add to its useful mileage per year, is worthy of careful study. At the same time the necessity of meeting these conditions does not relieve the motive power official of getting the greatest possible economy out of the locomotive as an engine, after he has met the conditions noted, and if he does his whole duty he will be eager enough, in his attempt to

obtain this economy, to satisfy the most enthusiastic student of the steam engine.

In connection with the shops and the work done in them there are numerous business problems. It is not given to every superintendent of motive power to locate and build up a great plant that shall meet the company's needs. But when such a plant is to be built, the same business considerations obtain as in the creation of a manufacturing establishment. Most of us, however, find on the roads we serve a more or less complete equipment of round houses and shops, with which we must do the best we can. Oftentimes these shops, in their location, size and character of their buildings, are far from being perfect, not necessarily because some one blundered when they were built, but because no one could foresee the extent of the growth of the company's business and the extension of its track and equipment. Furthermore, as most of our large railroad systems have reached their present size by the consolidation and absorption of smaller lines, each of which, when independent, had shops of its own, it is not

surprising to find a system provided with many shops, more or less completely equipped for doing the work of general repairs, and yet not one of them with all the facilities for doing work cheaply and on a large scale. This situation presents another business problem. The round houses, also, may have been originally located with reference to the needs of the short lines now consolidated into the larger system, and with the practice of having our locomotive runs average but little more than one hundred miles, which prevailed until recent years, these houses may all be in use. Again, we have a business problem before us. Every such point involves certain expenditures for superintendence, etc., and the smaller the number of locomotives handled at a given point the higher the ratio of these expenditures to the total outlay. Then the cost of dispatching and round-house labor is not dependent upon the length of the run the locomotive has made, but is as great for a trip of one hundred miles as it is for two hundred miles. Consequently, where division terminals can be so

changed as to give the locomotives longer runs, round houses can be closed, resulting in a considerable reduction in the amount of labor required to handle locomotives at terminals, as well as a material reduction in the cost of the labor remaining to be done in the houses retained. Another advantage gained is the greater mileage that can be obtained from locomotives when the runs are lengthened.

If we find the number and equipment of the shops to be as already indicated, a change will be necessary, if the cost of repairs is to be reduced to a minimum. You will remember that we assumed the repairs would cost four cents per mile. That amounts to \$1,440 per locomotive per annum, or \$1,440,000 per 1,000 locomotives. If we can reduce the figure by one-half cent per mile, the cost per annum will be reduced by \$180,000. To effect such a reduction we must have improved machinery and up-to-date methods. But much of this machinery, if installed in a small shop, would be idle most of the time—so

much of the time that it might not pay to purchase it unless more work can be found for it. To illustrate: Suppose a railroad finds it has no boiler shop that is properly equipped for economical work; at one of its main shops it takes out antiquated machinery, such as old punches and shears, single-spindle post-drills, bending rolls, operated by hand, etc., and in the place of this machinery is installed a powerful punch with throat deep enough to permit reaching the center of the widest sheet to be operated upon, a modern shear, an hydraulic riveting machine with at least a twelve-foot gap, multiple-spindle drills, power bending rolls, an hydraulic flanging machine, and other modern machinery, including traveling cranes. All hand work is now reduced to a minimum, and the shop is prepared to do the best of boiler work with great economy over the old methods. When this is accomplished it will be found that the shop is capable of doing a much larger amount of work than formerly; in fact it can probably do the heavy boiler work for 800 locomotives, even if in its equipment there was

installed only one of each of the more important tools. It will not pay to improve every boiler shop on the road in this manner, nor will it be necessary. By concentrating the heavy boiler work at a few places the maximum of economy can be obtained and with the minimum capital invested in tools. And so we might go through the blacksmith shop, machine shop and other shops and find many similar cases where the introduction of improved machinery and methods must go hand-in-hand with a concentration of the class or classes of work affected thereby.

Now nothing is more certain than the need of modern methods and first-class machinery in railroad shops; from which it follows that concentration of work must be accomplished, at least to the extent of keeping properly employed this modern machinery. This leads us to turn our attention to the small shops on the various divisions, with a view of deciding how much of the work performed in them can be profitably transferred to the larger and better equipped shops.

We may find that with proper round-house facilities for making the running repairs, some of them can be closed entirely. In such cases we gain not only the benefit of a lower cost on the work thus transferred to a better equipped shop, but we save in such items as light, heat, power, superintendence, etc. As superintendence itself is a large item—amounting to about ten per cent. of the total expenses of the department—the saving in this direction is not inconsiderable. There will still remain, however, numerous shops that must be maintained, and in which certain classes of repairs can be as cheaply done as in the main shops. It will be found economical, nevertheless, to take from them the heaviest classes of repair work, and also to relieve them of the manufacturing of much of the standard materials.

Perhaps I have used the word manufacturing unadvisedly, for if each outside shop is allowed to furnish all the new parts necessary in the course of its repair work there will be little manufacturing done. When a locomotive is overhauled, such parts as driving boxes, shoes and wedges,

rods, crank pins, cross-heads, etc., need more or less work done upon them to take up the wear, and evidently such work never can be put upon a manufacturing basis. Here and there a new crosshead, crank pin, driving box or other part is needed, but in many shops the number required at any one time is too small to introduce the labor-saving methods that would be possible if they were made in quantity. Evidently, however, if the main shop undertook to supply these parts in a finished condition to all the outlying shops, they could be made in such quantities as to greatly reduce their cost. This, I believe, is what should be done, and to a larger extent than is usually practiced. The main shops should undertake to make on a large scale as many of the new parts required in repairs over the system as the conditions will admit of, and this work should be done upon a manufacturing basis so far as practicable. By this means the cost is reduced and there is every incentive to keep on cheapening the work and raising the quality of it by special

and ingenious methods, by templates, jigs, special cutters and other tools.

To carry out this policy, two things are necessary: A standardizing of the parts of the various locomotives owned by the company, and liberal appropriations for the machinery needed in the work. The appropriations are matters which must be settled by the management. Without them these economies can not be effected and it is a matter of regret at times that there is not more money forthcoming for these purposes. But we will assume that this matter has been satisfactorily disposed of and consider for a moment the work of standardizing.

When you stop to think of the rapid changes that have taken place in locomotive design in the last ten years, by which steam pressures have been increased about fifty pounds and the size and weight of locomotives greatly augmented, you will readily understand that railroad companies which have purchased many engines in that time have a variety of designs in service. The consolidation of companies has in some cases

added to the variety of equipment under the care of the motive-power department. To manufacture parts for these engines it is necessary to use the same patterns and sizes on as many engines as possible. By so doing the quantity of stock required to be kept on hand will be less—a most important consideration. To show you the need that may exist for standardizing and what can be accomplished I will quote you a few of the results obtained along this line in the motive-power department with which I am connected.

We have reduced to one or two sizes most of our cocks and valves, oil cups, injector checks, glands and all other brass work and small parts. At one time we had 113 different kinds of cabs on the 1,010 engines owned by the company; now their number has been reduced to nine. Pilots at one time were built of fifteen different heights; now there are but three. The number of kinds and sizes of smoke stacks have been reduced from legion to four. Two patterns of exhaust pipes have replaced forty-five old ones. Ten cross-head patterns take the place of twenty formerly

used. Three standard eccentrics take the place of eleven needed heretofore. Sixteen cylinder head casings and seven cylinder head patterns have been discarded; also, six steam chests and casings. Six standard wheel centers now take the place of twenty-two formerly used. And so I might go through the entire list, but those already mentioned are enough to indicate the great saving that can be accomplished both in the stocks carried and the cost of production. Not a week passes without seeing more of this work accomplished; and yet, in it all, one must be constantly on the alert for improvements and must not hold these standards too sacred. They have to be discarded occasionally if we are to profit by our own experience and that of others. But with both large and small parts properly standardized and special tools and methods introduced, practically all the small standard parts can be manufactured at one shop and many of the large parts can be produced in the same way.

Some roads do nothing but repair work in their shops, but a few undertake to build quite a number

of their own engines. Rebuilding of locomotives is carried on to some extent in nearly every railroad shop. Where to draw the line in rebuilding it is difficult to determine. By this term I do not mean the making of extensive repairs and yet retaining the original design. Most roads find themselves possessed of engines of moderate size, provided with boilers much too small for the cylinders, and carrying a low steam pressure. If these engines were rebuilt and given new boilers the tractive weight and power would be largely increased by the larger boiler and higher steam pressure. Whether it is advisable to do this depends upon the service the rebuilt engines are intended for. Perhaps I can best illustrate the manner in which this matter should be viewed by taking actual cases. A road needs for its passenger service an engine, the equivalent in power of a seventeen inch engine carrying 180 pounds of steam. Its modern power is all large and the seventeen and eighteen inch engines owned by it will not do the work because the boilers are too small and they only carry 140 to 150 pounds steam.

pressure. To rebuild one of these seventeen inch engines, giving it a new boiler, will cost, say four thousand five hundred dollars. I believe it will pay to do it, if the machinery is heavy enough for the higher pressure, as a new engine for the service required will cost about eight thousand dollars. We save not only the difference in the cost, but we have one less small engine on our hands. But suppose we expect to use these rebuilt engines in freight service and have no particular place for them, but only contemplate increasing their capacity by the rebuilding, we would gain about twenty per cent. in power by the change. If the tractive power of the old engine be expressed by the number 100, then three engines rebuilt would have a total tractive power of 360. The cost of rebuilding the three engines would be thirteen thousand five hundred dollars. Now if we leave the old engines as they are and spend eleven thousand five hundred dollars of this money in purchasing a heavy modern freight engine we will be able to get one with a tractive power represented by 175, and

we would then have four engines, three old and one new, with a combined tractive power represented by 475, or an average of 118.75 per engine. If we should scrap one of the seventeen inch engines we would have three engines with a tractive power of 375, or an average of 125. Thus we find that for two thousand dollars less money we can, by purchasing new power and keeping all our old power, get almost exactly the same average tractive power as by rebuilding, and that if we would scrap one old engine for each new one purchased the average tractive power of our engines would be considerably increased over what we could obtain by rebuilding. Evidently the figures are against rebuilding except where the rebuilt engines will fit into some particular place, generally in passenger service.

I have shown you enough of the work of the motive-power department to make it evident that to successfully carry on a business as large as we have been considering, a complete and thorough organization is necessary. The peculiar character of the work, involving shop management

on the one hand and the control of a large body of men and the movement of many locomotives on the other, maintenance of the locomotives already owned and the designing of new ones, and the necessity of carrying on some of this work at points widely separated from each other, are all arguments against the possibility of any one man giving the details of this work his personal supervision. And to trust these details to others, a unity of purpose and practice is required. The business at each point must be conducted as a part of the great whole and not on independent lines. Improved methods or designs worked out at one point should become the practice at all others, if capable of more than a local application; in this manner only can advantage be taken of the ability and ingenuity of those in charge at each and every point. Without this unity, standards would soon be disregarded and would be of little value because they would not be based upon the experience of the whole department. A successful organization must not only assign to each person in it certain responsibilities and duties, but

it must be of such a character as to utilize the best work of each one. By giving to all as much of a voice in shaping the policies of the department as is consistent with the responsibility which must rest with the head of the department, I believe the best results will be obtained. If the men in charge at the various offices of a large department are asked to carry out instructions issued from headquarters without being consulted as to the effect of such instructions upon their work, the faithfulness with which they may carry out orders will never compensate for the loss to the department of the judgment and experience of these men, and the free expression of opinion which should prevail. Without attempting to lead you into the details of organization, I can assure you that, after the selection of capable men to fill the various positions of responsibility, an organization that will call out the hearty co-operation of each and every one of them is essential to the success of the work.

Co-operation, however, should not be confined to those in official positions. The further this

spirit of co-operation can extend into the rank and file of the department, the better it is for the company, its officers and the men themselves. This desirable result can be brought about by honest, fair dealing toward the men by those in authority over them. There is a wonderful amount of loyalty on the part of the men towards a great railway corporation that always endeavors to treat them justly, and fortunate is the company that wins that loyalty. Its value can not be computed. Many corporations, and many officials possess it, and they have won it without yielding any of their own rights to the men, but simply by according them justice at all times. We need to bear in mind constantly that our employes are men and that a large percentage of them are manly men and should be treated as such. With this thought directing our dealings with them we cherish those much-to-be-desired relations between employer and employe, that conserve the interests of both.

Statistics are usually so uninteresting that I have made but little use of them this evening.

Properly kept they are, however, of great value. By their use the business of the department can be grasped in its entirety. But in order that they should not mislead, they must not only be accurate, but must be on the right basis. In the past nearly all of the statistical work of the department has been computed on the engine-mile basis. In many respects this is most undesirable, as the engine-mile is far from being a constant unit. The ton-mile is a much better basis for much of our statistical work. Already we have placed all our coal records on this basis, and it is probably only a question of time when repairs and supplies will be computed in like manner. The importance of this matter is nicely illustrated in our coal records. On the engine-mile basis the engineer who hauled the lightest train made the finest showing, other things being equal. On the ton-mile basis the man who hauls the heaviest train may expect to have the best record. Thus we furnish an incentive to actual economy of operation, instead of putting a premium on extravagance. Furthermore, you can readily see that if

we had not considered the ton-miles we would not have seen any economy in fuel in our 750-ton train, as compared with a 600-ton train, in our example of engine-rating. The value of the ton-mile statistics are also illustrated by the records heavy modern power is making on many roads. When these engines are first put in service the men find they burn a large amount of coal per mile run, and use more oil than the smaller engines. Computing their fuel supplies and repairs on the ton-mile basis, however, the performance is seen to be a wonderful improvement over the smaller engines, and fully justifies their use on divisions whose business is heavy enough to properly utilize them. It will be clear upon reflection that the statistics on the ton-mile basis would determine the true cost for a unit of work ; and furthermore, as this unit is also a fairly accurate measure of the value of the service rendered the company, we are able at all times to determine with a fair degree of accuracy the cost of the locomotive performance per unit of revenue-producing service.

In my address to you this evening I have endeavored to keep within the limits of the subject assigned to me, and have avoided as much as possible the discussion of technical matters. The business problems of the motive power department are so numerous, however, that it would have been impossible in the time at my disposal to have touched even lightly upon them all. I have preferred, therefore, to take up only a few that confront us, with the hope that they would demonstrate how essential is the proper solution of such problems to the success of the work of the department. These problems are not new, and in the near future some of them may cease to exist, their place being taken by others, brought about by new conditions and the rapid progress being made in economic railroad operation. The tendency of passenger and freight rates is steadily downward, and that the railroads may live on the reduced rates the cost of operation must decrease likewise. The motive-power department must contribute its share to the reduction of expenses, and must do it by giving careful attention to its business problems.

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